The astronomical unit gets fixed

Earth–Sun distance changes from slippery equation to single number.

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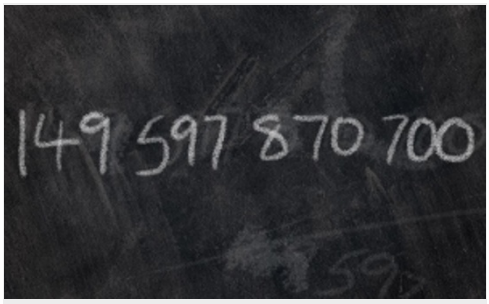
Without fanfare, astronomers have redefined one of the most important distances in the Solar System. The astronomical unit (au) — the rough distance from the Earth to the Sun — has been transformed from a confusing calculation into a single number. The new standard, adopted in August by unanimous vote at the International Astronomical Union's meeting in Beijing, China, is now 149,597,870,700 metres — no more, no less.



You are about this far from the Sun.

The effect on our planet's inhabitants will be limited. The Earth will continue to twirl around the Sun, and in the Northern Hemisphere, autumn will soon arrive. But for astronomers, the change means more precise measurements and fewer headaches from explaining the au to their students.

The distance between the Earth and the Sun is one of the most long-standing values in astronomy. The first precise measurement was made in 1672 by the famed astronomer Giovanni Cassini, who observed Mars from Paris, France, while his colleague Jean Richer observed the planet from French Guiana in South America. Taking the parallax, or angular difference, between the two observations, the astronomers calculated the distance from Earth to Mars and used that to find the distance from the Earth to the Sun. Their answer was 140 million kilometres — not far off from today's value.

Until the last half of the twentieth century, such parallax measurements were the only reliable way to derive distances in the Solar System, and so the au continued to be expressed as a combination of fundamental constants that could transform angular measurements into distance. Most recently, the au was defined as (take a deep breath): "the radius of an unperturbed circular Newtonian orbit about the Sun of a particle having infinitesimal mass, moving with a mean motion of 0.01720209895 radians per day (known as the Gaussian constant)".

The definition cheered fans of German mathematician Carl Friedrich Gauss, whose constant sits at the heart of the whole affair, but it caused trouble for astronomers. For one thing, it left introductory astronomy students completely baffled, says Sergei Klioner, an astronomer at the Technical University of Dresden in Germany. But, more importantly, the old definition clashed with Einstein's general theory of relativity.

As its name implies, general relativity makes space-time relative, depending on where an observer is located. The au, as formerly defined, changed as well. It shifted by a thousand metres or more between Earth's reference frame and that of Jupiter's, according to Klioner. That shift did not affect spacecraft, which measure distance directly, but it has been a pain for planetary scientists working on Solar System models.

The Sun posed another problem. The Gaussian constant is based on Solar mass, so the au was inextricably tied to the mass of the Sun. But the Sun is losing mass as it radiates energy, and this was causing the au to change slowly as well.

The revised definition wipes away the problems of the old au. A fixed distance has nothing to do with the Sun's mass, and the metre is defined as the distance travelled by light in a vacuum in 1 / 299,792,458 of a second. Because the speed of light is constant in all reference frames, the au will no longer change depending on an observer's location in the Solar System.

Redefining the au has been possible for decades — modern astronomers can use spacecraft, radars and lasers to make direct measurements of distance. But "some of them thought it was a little bit dangerous to change something," says Nicole Capitaine, an astronomer at the Paris Observatory in France. Some feared the change might disrupt their computer programs, others held a sentimental attatchment to the old standard. But after years of lobbying by Capitaine, Klioner and others, the revised unit has finally been adopted.

Capitaine and Klioner say that the streamlined au is already having a positive impact on their lives. Lobbying for the change has been time-consuming, Capitaine says: "I will have more time to devote to my research."

"I'm happy that I don't have to explain it to my students any longer," adds Klioner. The new definition "is much easier to understand now for everybody."

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- Corrections

Corrected: The article originally stated that under the old definition the au would shift by a thousand kilometres if calculated from the orbit of Jupiter. It would in fact change by a thousand metres. The text has been changed to reflect this.

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